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ON THE INTENSITY AND POLARIZATION OF FORBIDDEN LINES OF THE ION Fe XIII IN THE SOLAR CORONA

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ON THE INTENSITY AND THE POLARIZATION OF FORBIDDEN LINES OF THE ION Fe XIII IN THE SOLAR CORONA *

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SUMMARY

The intensities I and the polarization rates p of the forbidden lines $\lambda\lambda$10 747 – 10 798 - 3 388 Å of the ion Fe XIII in the presence of a radial magnetic field are computed.- Conclusion: 1) p (10 747) increases regularly with the distance to the center of the disk, r, and for $r = 1.8\ R_\odot$ reaches already a value of 0.6; 2) p(10 798) is < 0.1 for $r \leqslant 1.8\ R_\odot$; 3) p(3 388) is ≤ 0.03; 4) the anisotropy of the exciting radiation field has a feeble influence on the ratio $\mathcal{R} = I(10\,798) / I(10\,747)$; the values of electron density, formerly derived from this ratio while neglecting this effect. thus remain valid.

* * *

Several studies relative to the ion Fe XIII in the solar corona have been carried out with the assumption that the excitations and de-excitations are both, radiative and collisional, and with the hypothesis of a diluted and isotropic field at 6 000° K temperature for the photoexcitations [1, 2, 3]. They have shown that the intensity ratio of the forbidden lines λ10 798 and λ10 747 Å, in the coronal conditions, varied a great deal more with the electron density N_e than with the other parameters, such as the electron temperature T_e, the distance to disk's center r.- These two lines are situated in an unfavorable spectral interval for the receivers; however, they could be measured with a sufficient precision to derive from their intensity ratio $\mathcal{R}$ the values of the effective electron density [1].

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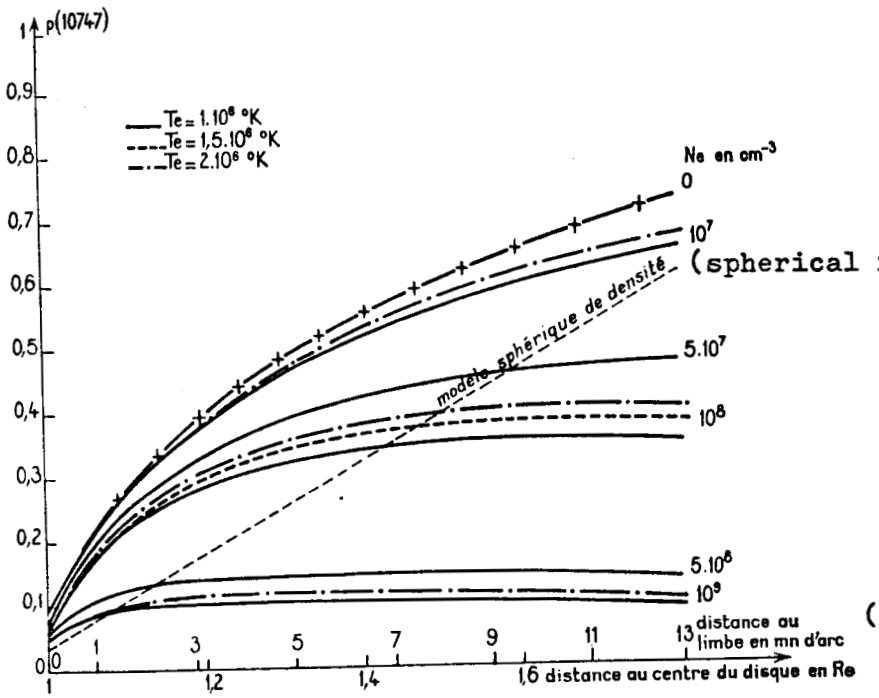
* Sur l'intensité de la polarisation des raies interdites de l'ion Fe XIII dans la couronne solaire.

The works by Charvin [4, 5, 6] on the polarization and intensity of the forbidden lines of the solar corona allow to obtain, without calculating the populations, the polarization and the intensity of coronal emission lines, provided the fundamental configuration of ions can be reduced to two levels. In the case of Fe XIII (five levels in the fundamental configuration) it is necessary to effect the complete calculations so as know the polarizations of the three lines $\lambda\lambda$ 10 747 — 10 798 — 3 388 Å.



(spherical model of density)

(distance to the limb in min. of arc)

(distance to the center of the disk in R_E).

Fig. 1. Polarization rate of the line λ 10 747 Å as a function of the distance to the center of the disk with N_e and T_e in parameter.

I, thus, completed the previous calculations [1], with the intervention of the anisotropy of solar radiation field and the decomposition of the levels into Zeeman sub-levels.

The statistical equilibrium equations are written for each of the (2J + 1) sub-levels of the four first energy levels of Fe XIII, taking into account the following processes described in [4]: excitations and de-excitations by collisions, spontaneous emissions, isotropic radiative absorptions, anisotropic radiative absorptions.

The depolarizations due to impact-induced transitions between the Zeeman sub-levels of a same energy level have not been taken into account for H. Van Regemorter [7] has shown that this process is negligible in coronal conditions.

RESULTS. - They are given for an element of volume after the formulas given in [4]. The polarization rate of λ10 747 Å is represented in Fig. 1 as a function of parameters r, N_e and T_c. For a spherical model

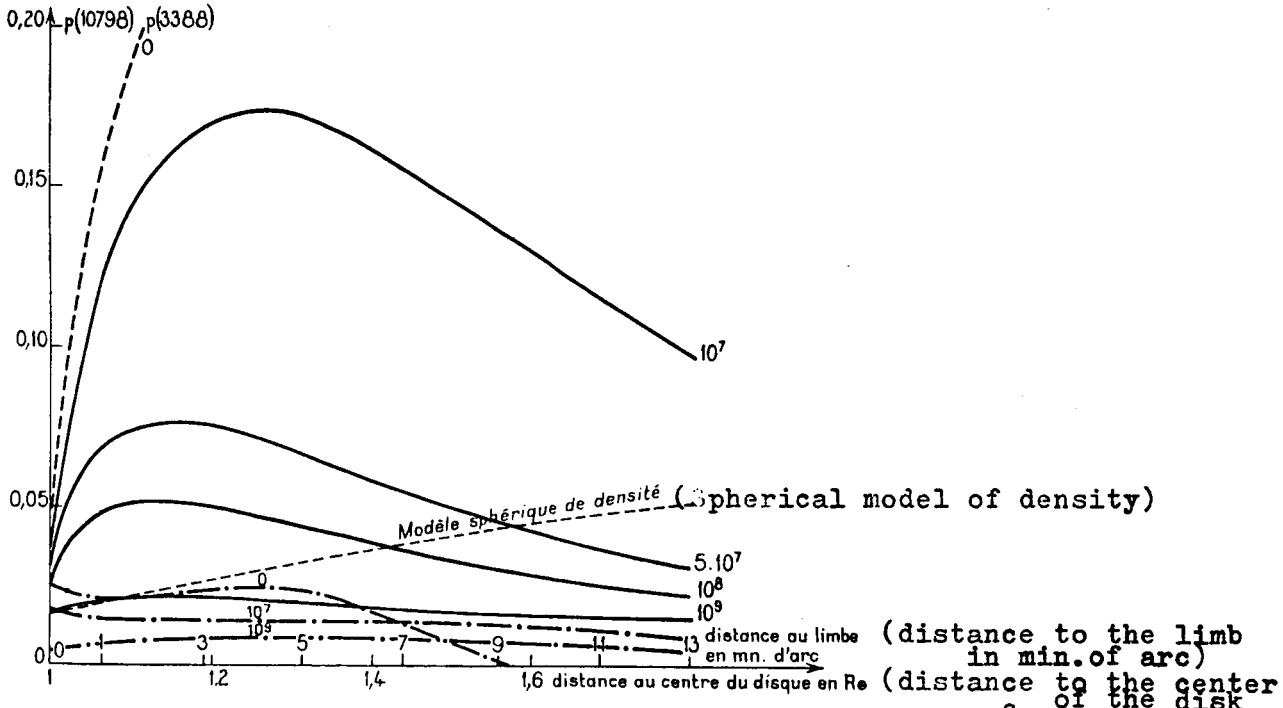


Fig. 2. - Polarization rate of the lines λ 10 798 and 3 388 Å, as a function of the distance to the center of the disk with N_e in parameter and for $T_e = 10^6$ °K.

——— line λ 10 798 Å ;
- - - - - - - line λ 3 388 Å.

of electron density twice as high as that for the Van de Hults model [8], p(10 747) passes from 0.1 at 1 min from the limb, to p (10 747) = 0.6 at 13 min, which seems to be in agreement with the limit value p = 1 found by Chavrin. The influence of the electron temperature is not very great; the span between the extreme curves, corresponding to $T_e = 1 \cdot 10^6$ and $2 \cdot 10^6$ °K, is 30 % at maximum. The measurement of p appears to be possible with the present-day means of detection, for this line is sufficiently

intense (about $50 \cdot 10^{-6}$ of solar luminance per angstrom) and its polarization remains relatively strong even near the limb.

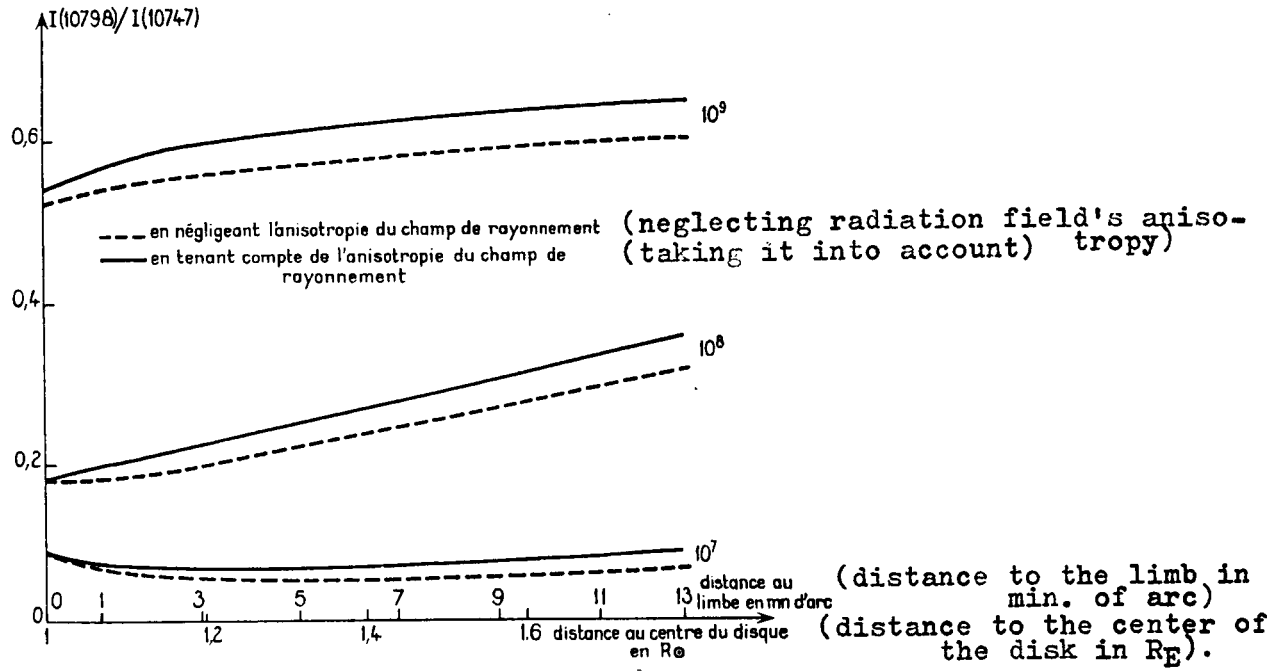


Fig. 3. - Ratio I (10 798) / I (10 747) as a function of the distance to the center of the disk with N_e in parameter and for $T_e = 10^{6}$° K.

Fig. 2 represents the polarization ratio of the lines λ 3 388 and λ 10 798 Å; these are low for the standard electron densities of the corona. The variations of p (3 388) are rather complex and for the theoretical case $N_e = 0$ the polarization becomes zero while changing the sign. The lines $\lambda\lambda$ 3 388 – 10 798 being themselves little intense, it seems to be very difficult to measure their weak polarizations.

Fig. 3 allows the comparison between the ratio $\mathcal{R}$ obtained by taking into account the anisotropy of the radiation field and the results obtained when neglecting it.[1]. The error introduced into $\mathcal{R}$ is an underestimate not exceeding 10%; taking into account the imprecision of the theoretical data and the precision obtained over $\mathcal{R}$, this effect may be neglected when one seeks to determine, starting from $\mathcal{R}$, the electron density of the corona near the solar limb.

DISCUSSION. - The calculations have been made while neglecting the higher energy levels of the ion Fe XIII and in the presence of a radial magnetic field. The present-day knowldge of the position and of the characteristics of the higher levels of Fe XIII are still very fragmentary. The only known thing is that these levels are partially populated by collisions, for several allowed lines have just been identified in the ultraviolet spectrum of the very low solar corona [9]. These levels, which stock the levels $^3P_0$, $^3P_1$ and $^3P_2$ by radiative cascades, must induce a depolarization, but the latter must be weak from the moment one drifts away from the limb.

The influence of the magnetic field has been discussed in [4], namely for the green line; for certain orientations of the magnetic field the polarization may nullify by changing sign. The currently-carried out calculations for the ion Fe XIII show already that the depolarization due to a non-radial magnetic field may be very great.

The values of polarization computed here are thus maximum.

**** THE END ****

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on 13 October. 1965

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